

ECG Report

DrHaitham Fahmey

Conduction System

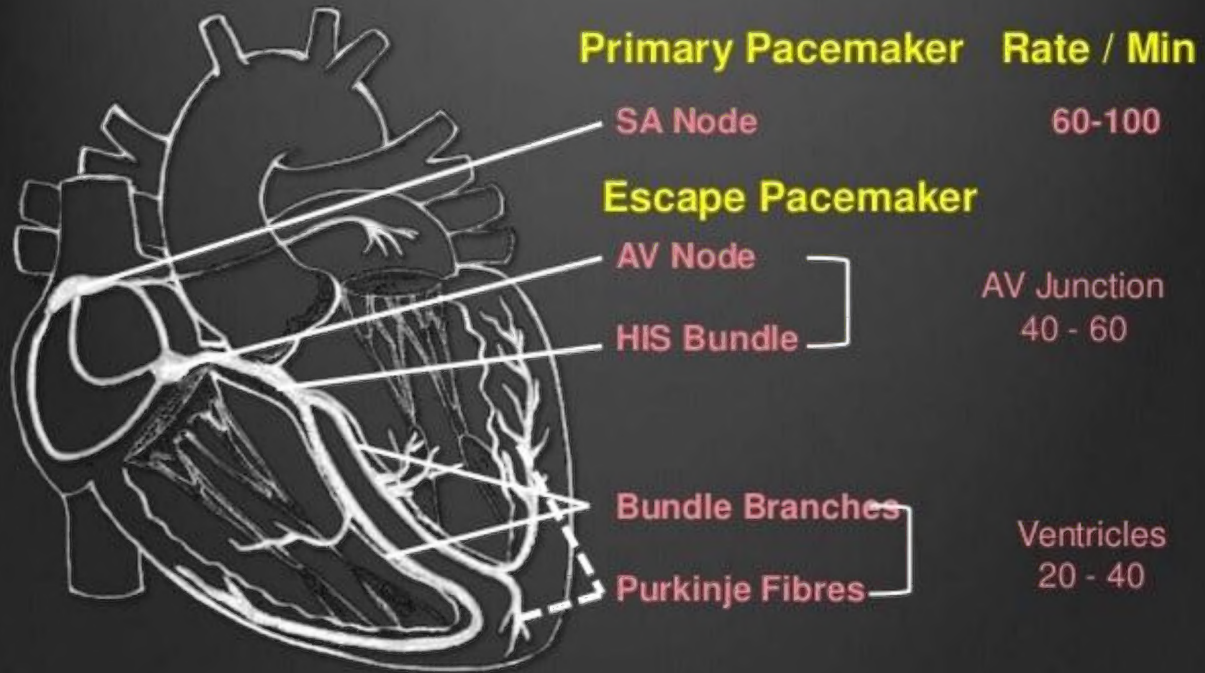
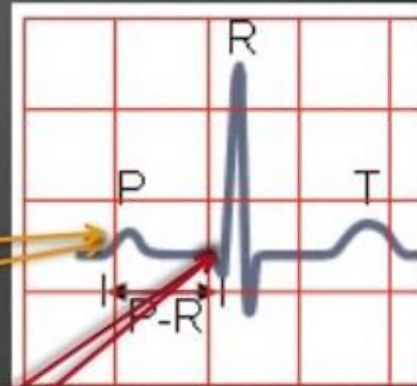
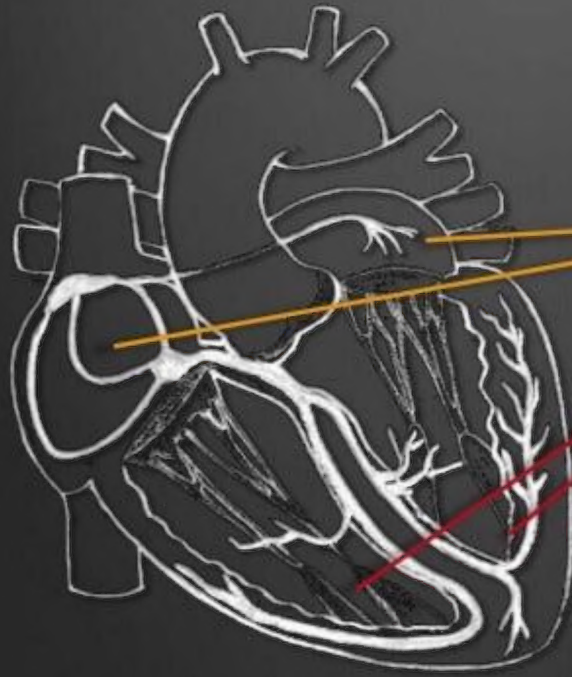


Image source : <http://www.ekgguru.com/content/conduction-system-illustration>

ECG Complex



Electrode placement in 12 lead ECG

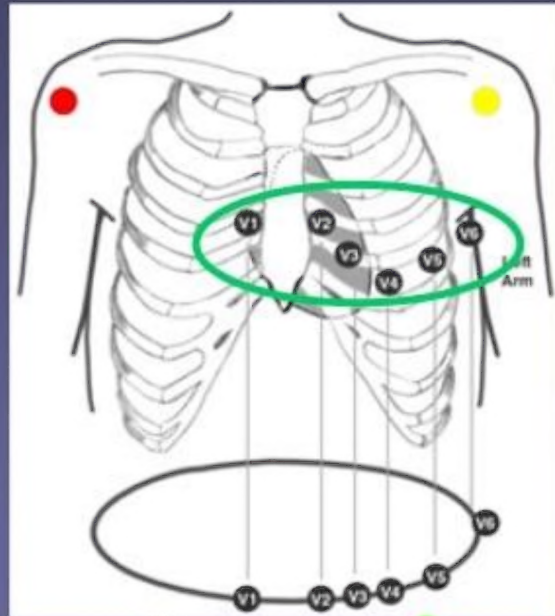
- 6 are chest electrodes
 - Called V1-6 or C1-6

- 4 are limb electrodes

- **Right arm** **R**ide
- **Left arm** **Y**our
- **Left leg** **G**reen
- **Right leg** **B**ike

- Remember

- The right leg electrode is a neutral or "dummy"!

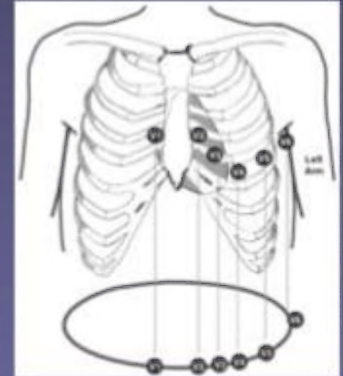


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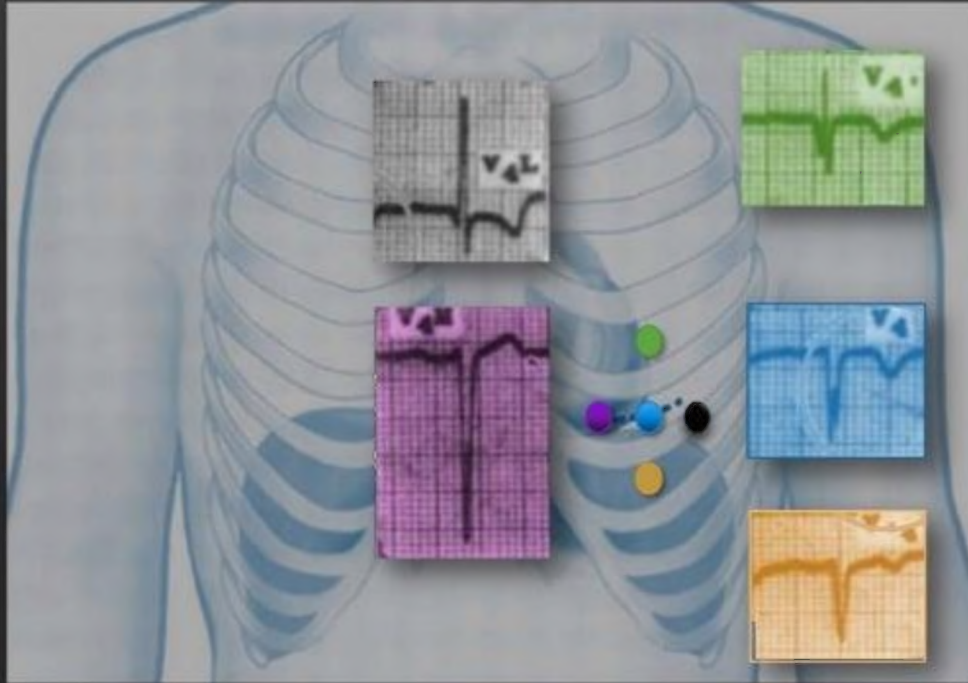
Electrode placement

For the chest electrodes

- V1 4th intercostal space right sternal edge
- V2 4th intercostal space left sternal edge
 - (to find the 4th space, palpate the manubriosternal angle (of Louis))
 - Directly adjacent is the 2nd rib, with the 2nd intercostal space directly below. Palpate inferiorly to find the 3rd and then 4th space
- V4 over the apex (5th ICS mid-clavicular line)
- V3 halfway between V2 and V4
- V5 at the same level as V4 but on the anterior axillary line
- V6 at the same level as V4 and V5 but on the mid-axillary line



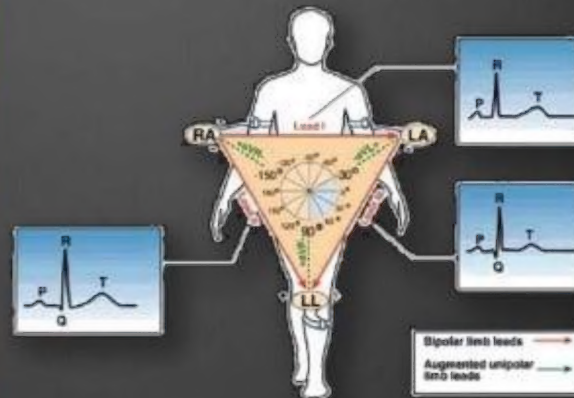
Lead Misplacement



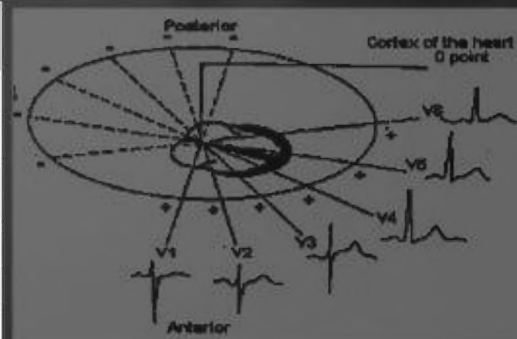
QRS-T changes secondary to shift of the V4 electrode

Standard Morphologies

Lead	P-Wave	QRS	T-Wave
Limb Leads – Vertical Plane			
I	↑	↑	↑
II	↑	↑	↑
III	↑	↑	↑
Augmented Leads			
aVR	↓	↓	↑↓
aVF	↑	↑	↑



Lead	P-Wave	QRS	T-Wave
Precordial Leads – Horizontal Plane			
V1	↑/±	Small R wave / QS	↑
V2	↑/±	Small R wave / QS	↑
V3	↑	Equiphase QRS / ↑	↑
V4	↑	↑	↑
V5	↑	↑	↑
V6	↑	↑	↑

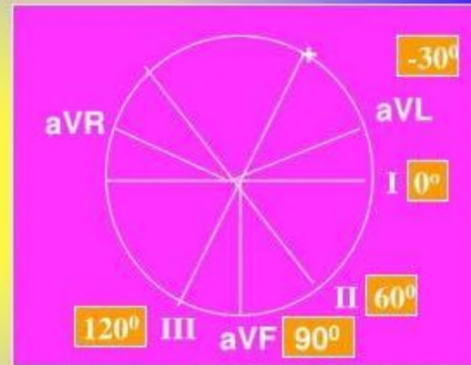
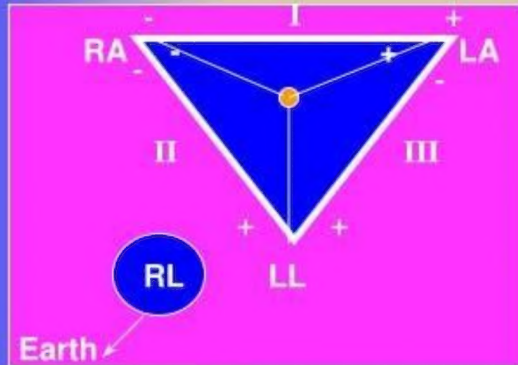


STANDARD LIMB LEADS

25. Recorded by placing (+) electrodes

in Right Arm (RA), Left Arm (LA), Left Leg (LL)

26. Recording ECG with



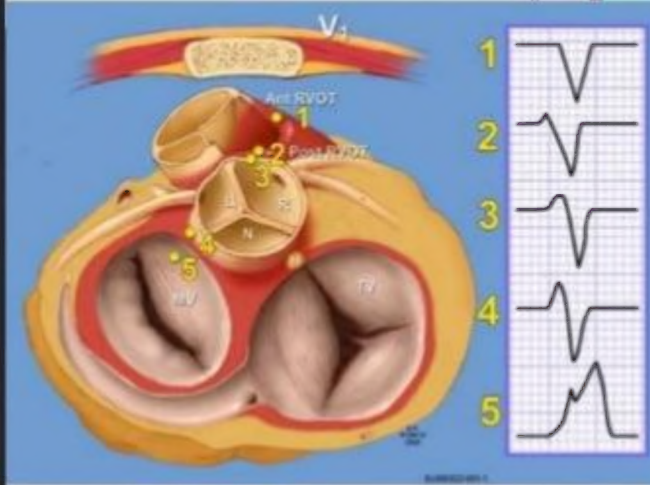
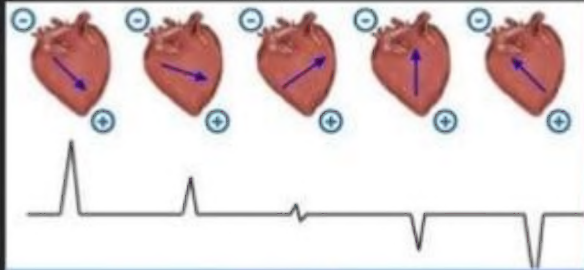
27. Positive electrodes placed in LA and LL why ?

Because current moving towards
a + electrodes produces a + deflection.

And that is what we want.

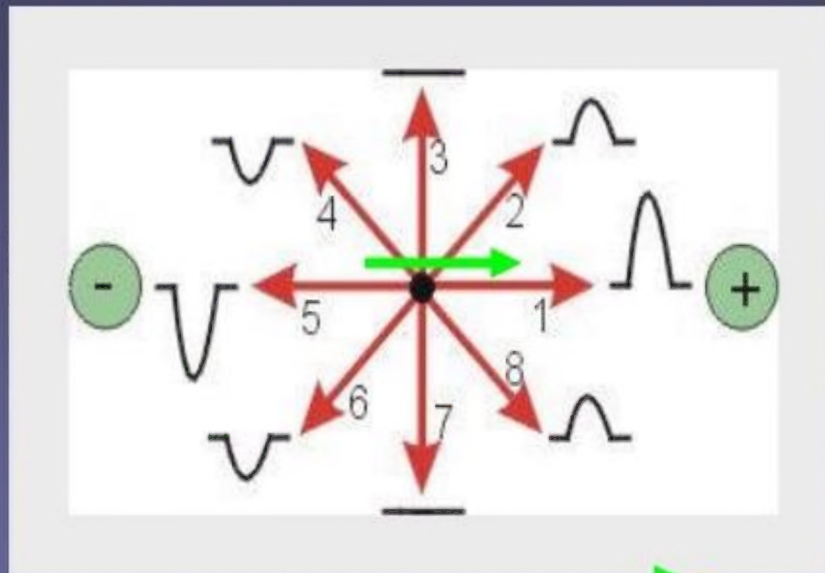


Depolarisation



Tabatabaei and Asirvatham: Circ Arrhyth 2010

Away from
the
electrode
= negative
deflection



Towards
the
electrode
= positive
deflection

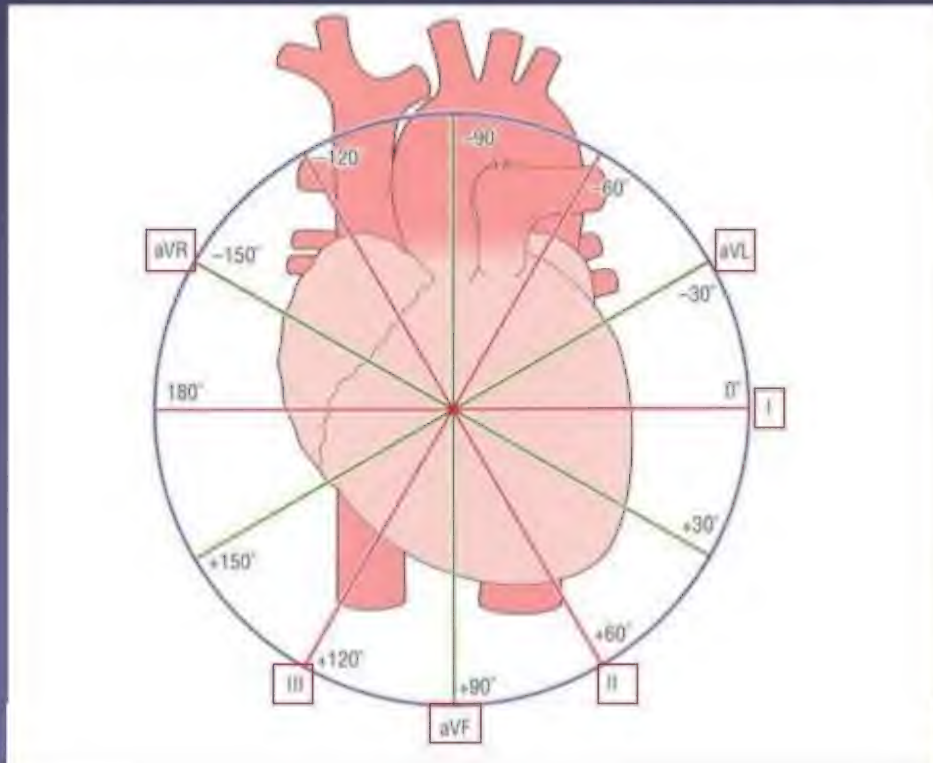
Direction of impulse (axis)

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Types of Leads

- Coronal plane (Limb Leads)
 1. Bipolar leads — I, II, III
 2. Unipolar leads — aVL, aVR, aVF
- Transverse plane
V₁ — V₆ (Chest Leads)

Electrodes around the heart



Lead Groups

- **Inferior Leads**
 - II, III, aVF
 - View from Left Leg ⊕
 - Inferior wall of left ventricle

I	II	III	aVR	aVL	aVF
II	III	aVF	V1	V2	V3
III	aVF	V1	V2	V3	V4
aVR	aVL	aVF	V4	V5	V6
aVL	aVF	V4	V5	V6	V7
aVF	V4	V5	V6	V7	V8



- **Lateral Leads**
 - I, aVL, V5 and V6
 - View from Left Arm ⊕
 - Left lateral chest wall / ventricle

I	II	III	aVR	aVL	aVF
II	III	aVF	V1	V2	V3
III	aVF	V1	V2	V3	V4
aVR	aVL	aVF	V4	V5	V6
aVL	aVF	V4	V5	V6	V7
aVF	V4	V5	V6	V7	V8



- **Anterior Leads**
 - V3, V4
 - Left anterior chest
 - ⊕ electrode on anterior chest

I	II	III	aVR	aVL	aVF
II	III	aVF	V1	V2	V3
III	aVF	V1	V2	V3	V4
aVR	aVL	aVF	V4	V5	V6
aVL	aVF	V4	V5	V6	V7
aVF	V4	V5	V6	V7	V8



- **Septal Leads**
 - V1, V2
 - Along sternal borders
 - Look through right ventricle & see septal wall

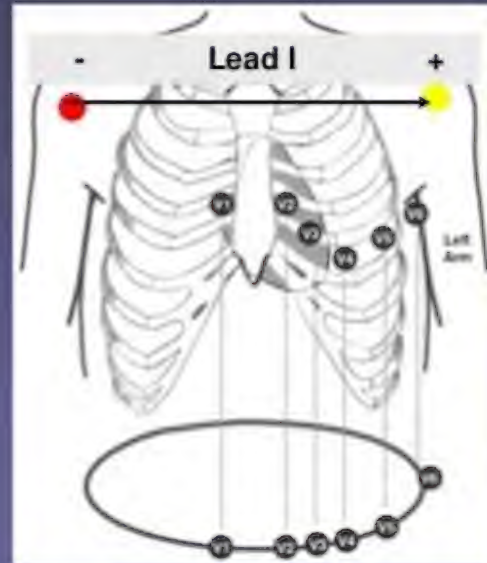
I	II	III	aVR	aVL	aVF
II	III	aVF	V1	V2	V3
III	aVF	V1	V2	V3	V4
aVR	aVL	aVF	V4	V5	V6
aVL	aVF	V4	V5	V6	V7
aVF	V4	V5	V6	V7	V8



Leads

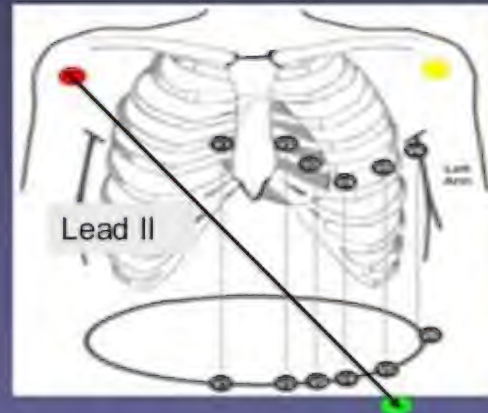
How are the 12 leads on the ECG (I, II, III, aVL, aVF, aVR, V1 – 6) formed using only 9 electrodes (and a neutral)?

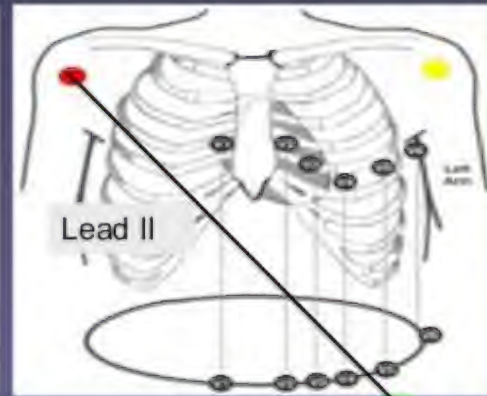
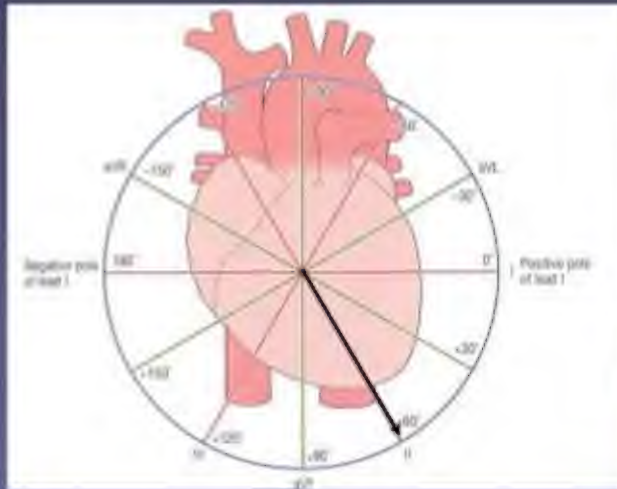
- Lead I is formed using the **right arm electrode (red)** as the negative electrode and the **left arm (yellow)** electrode as the positive



Leads

- Lead II is formed using the **right arm electrode (red)** as the negative electrode and the **left leg electrode** as the positive





Leads

- Lead III is formed using the **left arm electrode** as the negative electrode and the **left leg electrode** as the positive
- aVL, aVF, and aVR are *composite leads*, computed using the information from the other leads

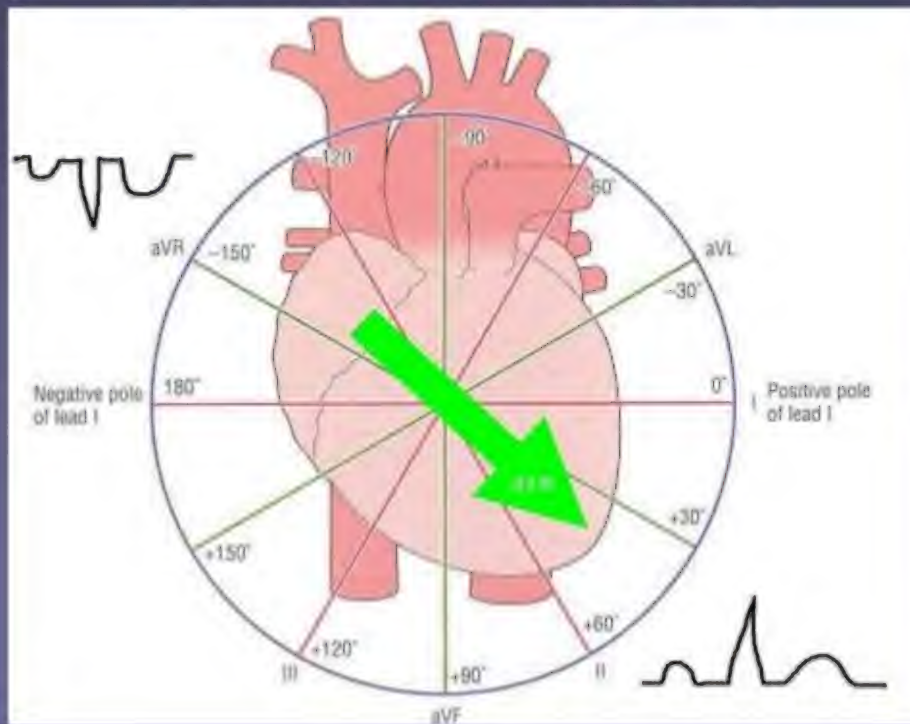
Leads and what they tell you

Limb leads

Limb leads look at the heart in the coronal plane

- aVL, I and II = lateral
- II, III and aVF = inferior
- aVR = right side of the heart

Leads look at the heart from different directions



Leads and what they tell you

Each lead can be thought of as 'looking at' an area of myocardium

Chest leads

V₁ to V₆ 'look' at the heart on the transverse plane

- V₁ and V₂ look at the anterior of the heart and R ventricle
- V₃ and V₄ = anterior and septal
- V₅ and V₆ = lateral and left ventricle

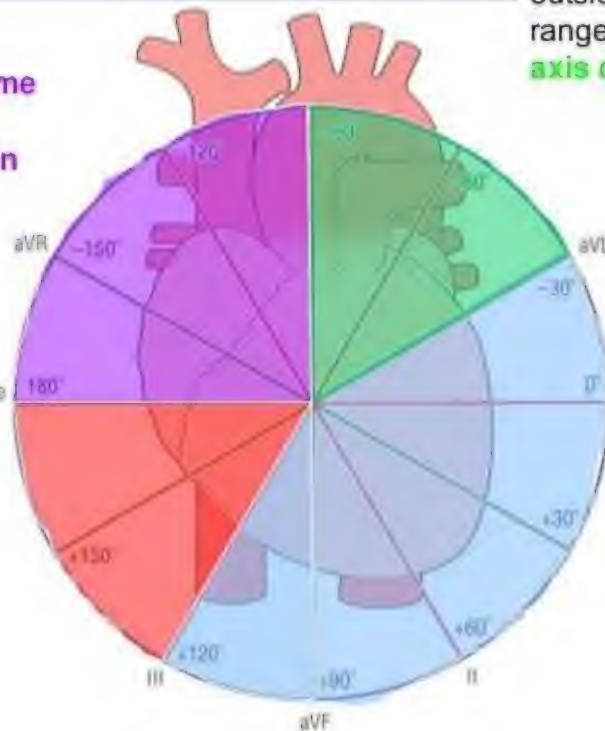
Axis

An axis falling outside the normal range can be **left axis deviation**

or **extreme axis deviation**

right axis deviation

Negative pole of lead I



A **normal axis** can lie anywhere between -30 and +90 degrees or +120 degrees according to some

IV. AXIS:

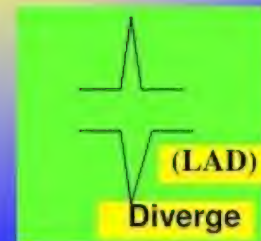
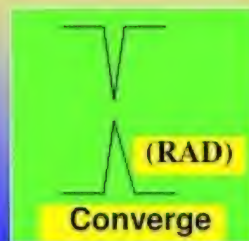
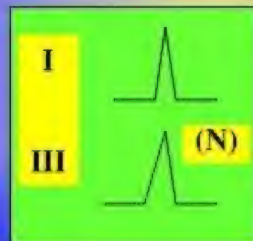
61. Axis - means electrical axis of heart



62. Determination of axis - Crude but simple method
study lead I and III alone


Net -ve

63.



Axis deviation - Causes

- Wolff-Parkinson-White syndrome can cause both Left and Right axis deviation

A useful mnemonic:

- “**RAD RALPH** the **LAD** from **VILLA**”

- **Right Axis Deviation**

- Right ventricular hypertrophy
- Anterolateral MI
- Left **P**osterior **H**emiblock

- **Left Axis Deviation**

- Ventricular tachycardia
- Inferior MI
- Left ventricular hypertrophy
- Left **A**nterior hemiblock

ECG Interpretation

- Step 1: What is the rate?
- Step 2: Is the rhythm regular or irregular?
- Step 3: Is the P wave normal?
- Step 4: P-R Interval/relationship?
- Step 5: Normal QRS complex?

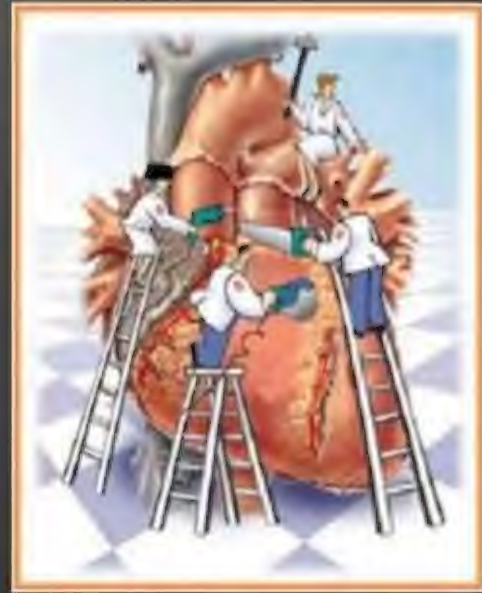


Image source : www.123rf.com

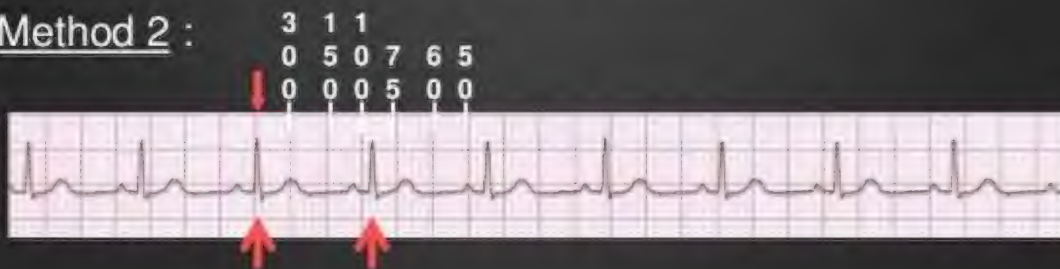
Step 1 : Rate

Method 1 : Count the number of R waves for a six second interval and multiply by ten.



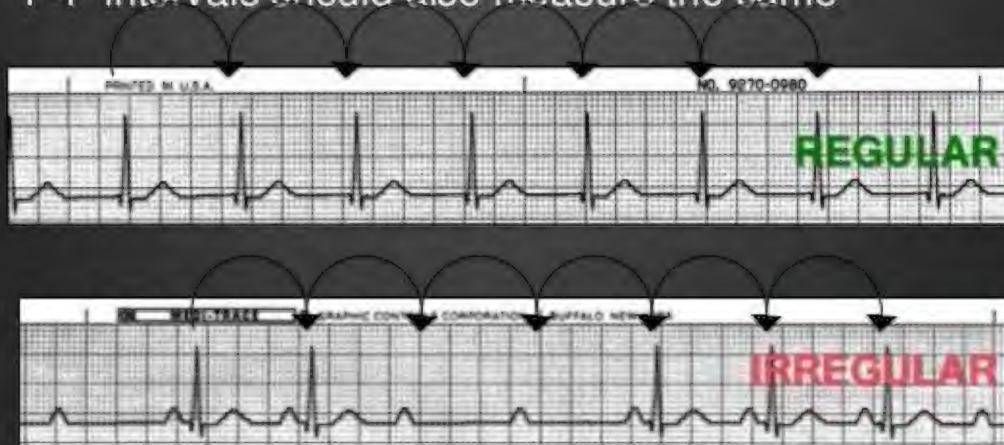
- Tachycardia exists if the rate is greater than 100 bpm.
- Bradycardia exists if the rate is less than 60 bpm.

Method 2 :



Step 2 - Rhythm

- Determine if the ventricular rhythm is regular or irregular
- R-R intervals should measure the same
- P-P intervals should also measure the same



STEP 3 : P Wave Morphology

- Identify and examine P waves:
 - Present?
 - Appearance?
 - Consistency?
 - Relation to QRS?

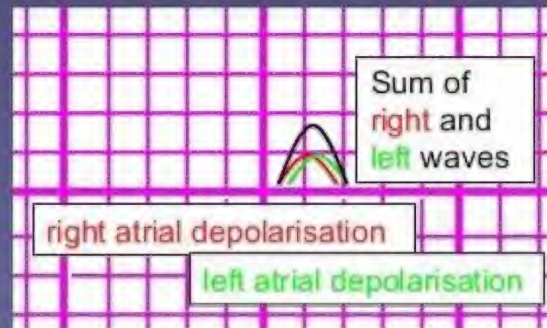
The P wave

The P wave represents atrial depolarisation

It can be thought of as being made up of two separate waves due to **right** atrial depolarisation and **left** atrial depolarisation.

Which occurs first?

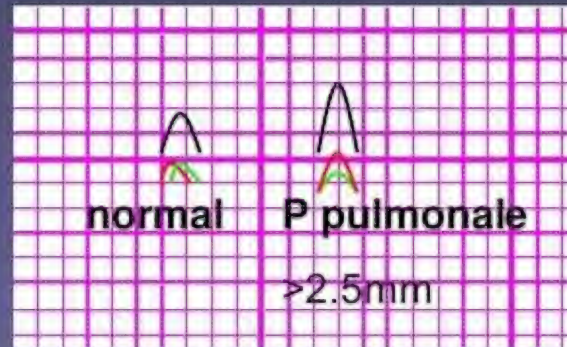
Right atrial depolarisation



The P wave

Height

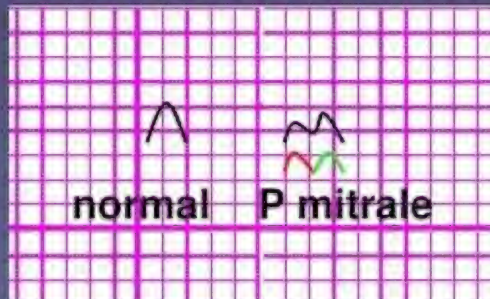
- A tall P wave (over 2.5mm) can be called *P pulmonale*
- Occurs due to **R atrial hypertrophy**
- Causes include:
 - pulmonary hypertension,
 - pulmonary stenosis
 - tricuspid stenosis



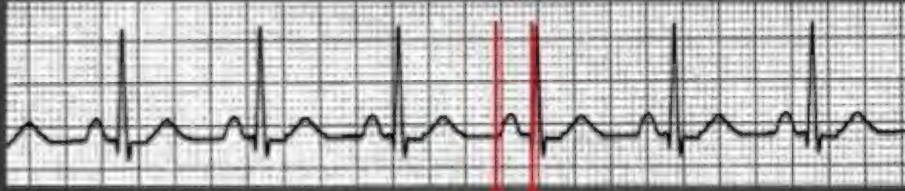
The P wave

Length

- A P wave with a length >0.08 seconds (2 small squares) and a bifid shape is called *P mitrale*
- It is caused by left atrial hypertrophy and delayed **left atrial depolarisation**
- Causes include:
 - Mitral valve disease
 - LVH



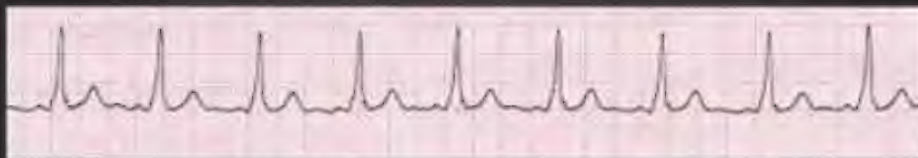
Step 4 : PR Interval



Consistent PRI of $< .20$ secs is normal



Lengthening of PRI is indicative of AV Nodal disease



Shortening of PRI is indicative of a bypass tract

The PR interval

- The PR interval is measured between the start of the P wave to the start of the QRS complex
- (therefore if there is a Q wave before the R wave the PR interval is measured from the start of the P wave to the start of the Q wave, not the start of the R wave)

The PR interval

- If the PR interval is short (less than 3 small squares) it may signify that there is an accessory electrical pathway between the atria and the ventricles, hence the ventricles depolarise early giving a short PR interval.
- One example of this is Wolff-Parkinson-White syndrome where the accessory pathway is called the bundle of Kent. See next slide for an animation to explain this

The PR interval

- If the PR interval is long (>5 small squares or 0.2s):
- If there is a constant long PR interval 1st degree heart block is present
- First degree heart block is a longer than normal delay in conduction at the AV node

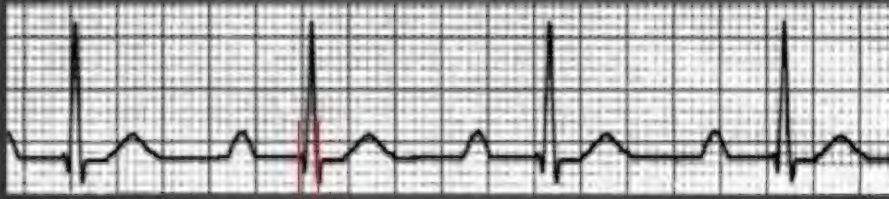
The PR interval

- If the PR interval looks as though it is **widening** every beat and then a QRS complex is missing, there is **2nd degree heart block, Mobitz type I**. The lengthening of the PR interval in subsequent beats is known as the Wenckebach phenomenon
- (remember (**w**)one, **W**enckebach, **w**idens)
- If the PR interval is **constant** but then there is a missed QRS complex then there is **2nd degree heart block, Mobitz type II**

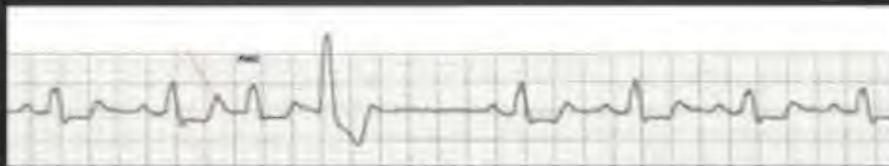
The PR interval

- If there is **no discernable relationship** between the P waves and the QRS complexes, then **3rd degree heart** block is present

Step 5 : QRS Duration



- A narrow QRS complex (< 0.12), indicates the impulse has followed the normal conduction pathway



- A widened QRS complex (> 0.12), may indicate the impulse was generated somewhere in the ventricles

QRS width

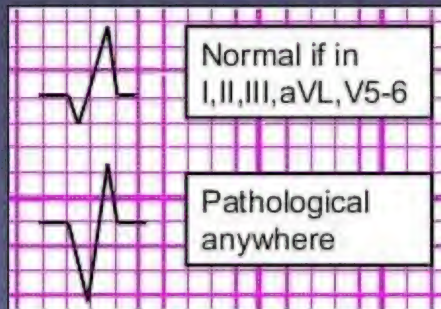
It is useful to look at leads V_1 and V_6

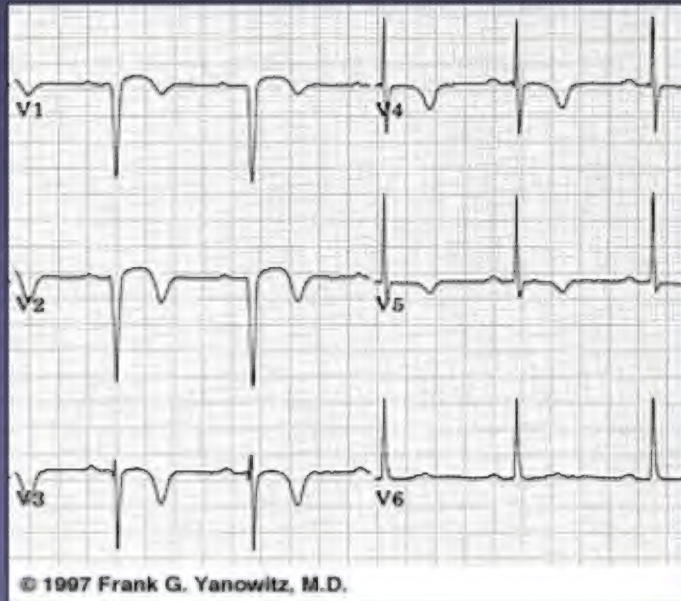
- LBBB and RBBB can be remembered by the mnemonic:
- **WiLLiaM MaRRoW**
- Bundle branch block is caused either by infarction or fibrosis (related to the ageing process)

The Q wave

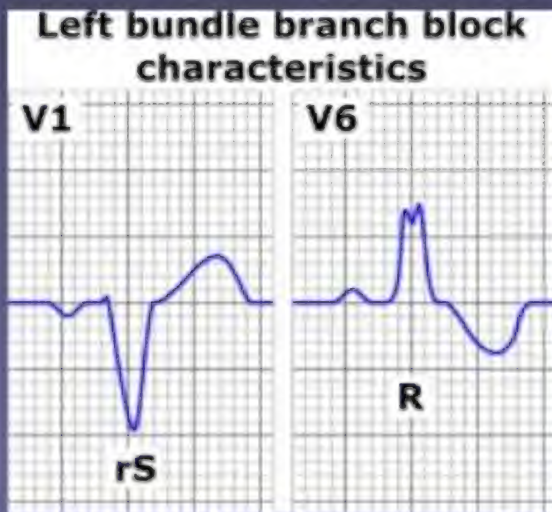
Are there any pathological Q waves?

- A Q wave can be pathological if it is:
 - Deeper than 2 small squares (0.2mV)and/or
 - Wider than 1 small square (0.04s)and/or
 - In a lead other than III or one of the leads that look at the heart from the left (I, II, aVL, V5 and V6) where small Qs (i.e. not meeting the criteria above) can be normal





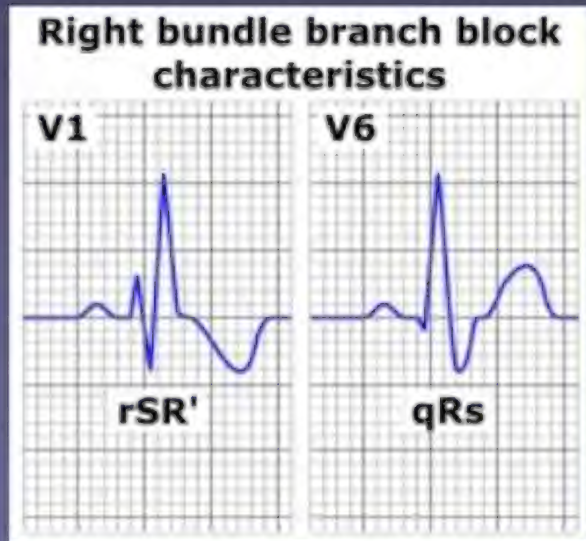
LBBB



- If **left** bundle branch block is present, the QRS complex may look like a '**W**' in V_1 and/or an '**M**' shape in V_6 .
- New onset LBBB with chest pain consider Myocardial infarction
- Not possible to interpret the ST segment.

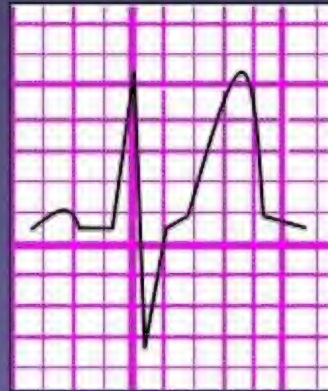
RBBB

- It is also called RSR pattern
- If **right** bundle branch block is present, there may be an '**M**' in V1 and/or a '**W**' in V6.
- Can occur in healthy people with normal QRS width – partial RBBB



The T wave

- Are the T waves too tall?
 - No definite rule for height
 - T wave generally shouldn't be taller than half the size of the preceding QRS
- Causes:
 - Hyperkalaemia
 - Acute myocardial infarction

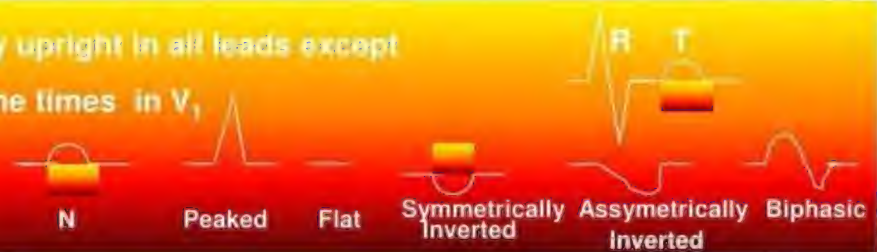


The T wave

- If the T wave is flat, it may indicate hypokalaemia
- If the T wave is inverted it may indicate ischaemia

X. T WAVE

79. T wave normally upright in all leads except in AVR and some times in V_1



80. T wave tall and peaked
Hyperacute phase of Infarction, Hyperkalemia



81. T wave Symmetrically inverted
in Ischaemia of Myocardium

T wave Asymmetrically inverted
In strain pattern of LVH ($V_5 V_6$) & RVH (V_1)



Myocardial infarction

- Within hours:
 - T wave may become peaked
 - ST segment may begin to rise
- Within 24 hours:
 - T wave inverts (may or may not persist)
 - ST elevation begins to resolve
 - If a left ventricular aneurysm forms, ST elevation may persist
- Within a few days:
 - pathological Q waves can form and usually persist

Lead Summary

I Lateral Circumflex Artery	aVR	V1 Septal Left Anterior Descending Artery	V4 Anterior Right Coronary Artery
II Inferior Right Coronary Artery	aVL Lateral Circumflex Artery	V2 Septal Left Anterior Descending Artery	V5 Lateral Circumflex Artery
III Inferior Right Coronary Artery	AVF Inferior Right Coronary Artery	V3 Anterior Right Coronary Artery	V6 Lateral Circumflex Artery

STAGE OF EVOLUTION OF IHD

88.



ST depression
during chest pain



Disappears
after chest pain

Angina Pectoris

89.



Ventricular
Activation time



ST
Elevation



Tall peaked
T wave

Hyper Acute
Phase of Infarction

90.



Path Q



ST Elevation



T Inversion

Acute
myocardial Infarction

IX ST SEGMENT

76. ST Segment - From End of S wave (J point)
- To beginning of T. wave

Normally - ST same plane as baseline or Isoelectric line



77. ST Segment Elevation (J point elevation of 1mm or more from baseline)
in comparison
to Isoelectric line



78. ST Segment Depression



Atrial Fibrillation

Features:

- There maybe tachycardia
- The rhythm is usually irregularly irregular
- No P waves are discernible – instead there is a shaky baseline
 - This is because there is no order to atrial depolarisation, different areas of atrium depolarise at will

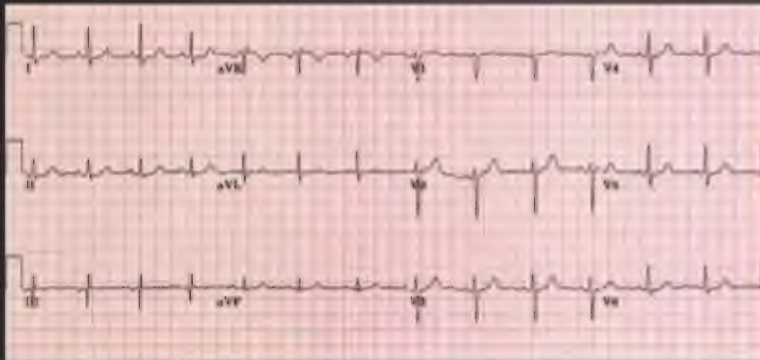
Atrial Fibrillation





Normal Sinus Rhythm

- ⊗ 1:1 AV synchrony (one atrial event for each ventricular event)
- ⊗ Stable rhythm with repeating patterns (60 – 100 bpm)
- ⊗ Morphologies of beats should be similar from complex to complex
- ⊗ Rate should be appropriate—not too fast, not too slow



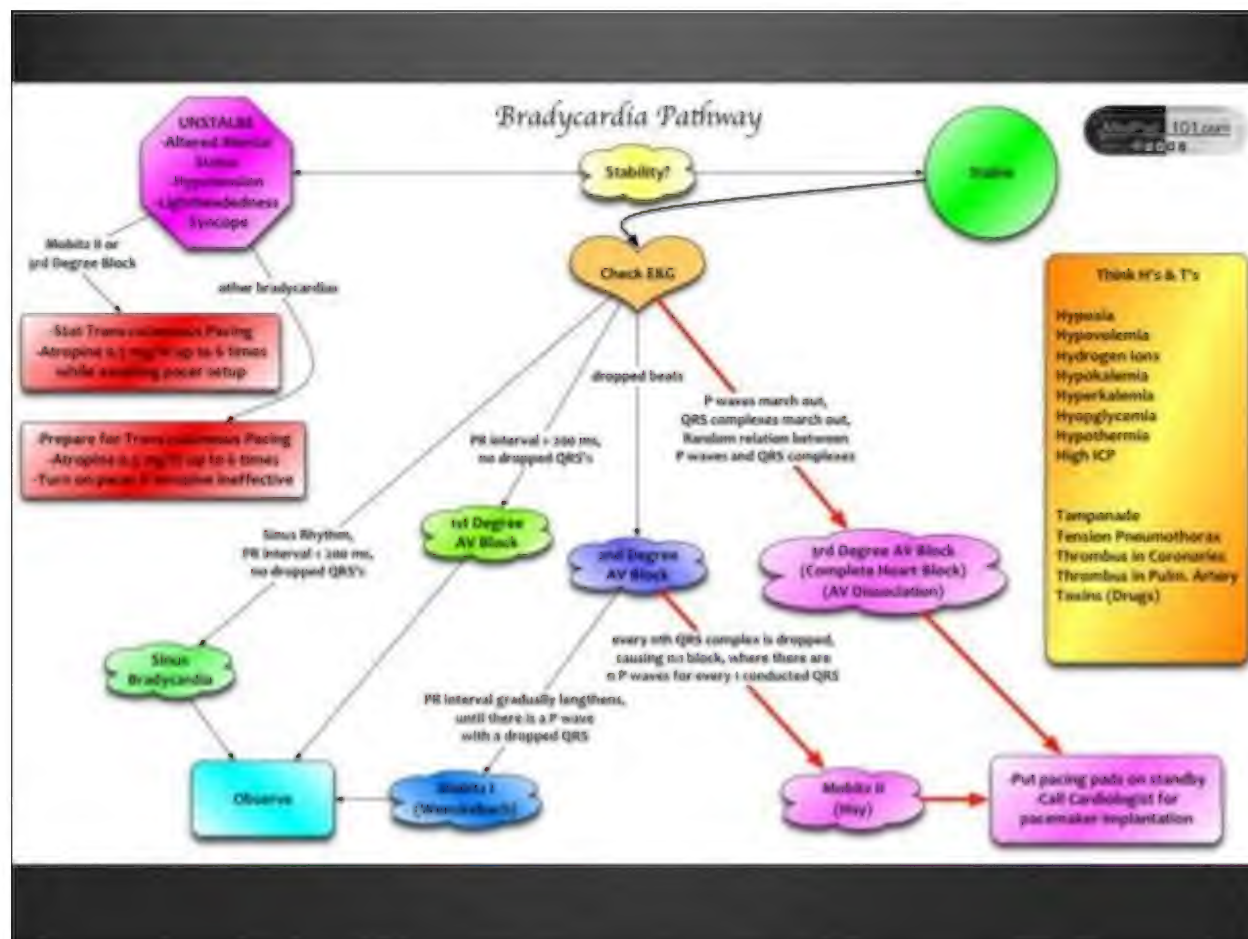
**NORMAL
SINUS
RHYTHM**

12 lead tracing source : http://meds.queensu.ca/courses/assets/modules/ts-ecg/Normal_ECG.bmp

Video source : Youtube.com

Abnormal Cardiac Rhythm

- Abnormally shaped waves
- Lack of 1:1 AV synchrony
- Rapid cardiac activity, even if otherwise stable
- Very slow cardiac activity, even if otherwise stable
- Irregular cardiac activity
- Variability in PR interval
- Pauses
- Premature beats (oddly timed events)



Conduction Blocks

**4:3
WENCKEBACH
SECOND
DEGREE
AV BLOCK**



Tachycardia (with pulses) Pathway

MediPulse 101 app
© 2008



Mechanism of Arrhythmia

- **Abnormal heart pulse formation**
 - Sinus pulse
 - Ectopic pulse
 - Triggered activity
- **Abnormal heart pulse conduction**
 - Reentry
 - Conduct block

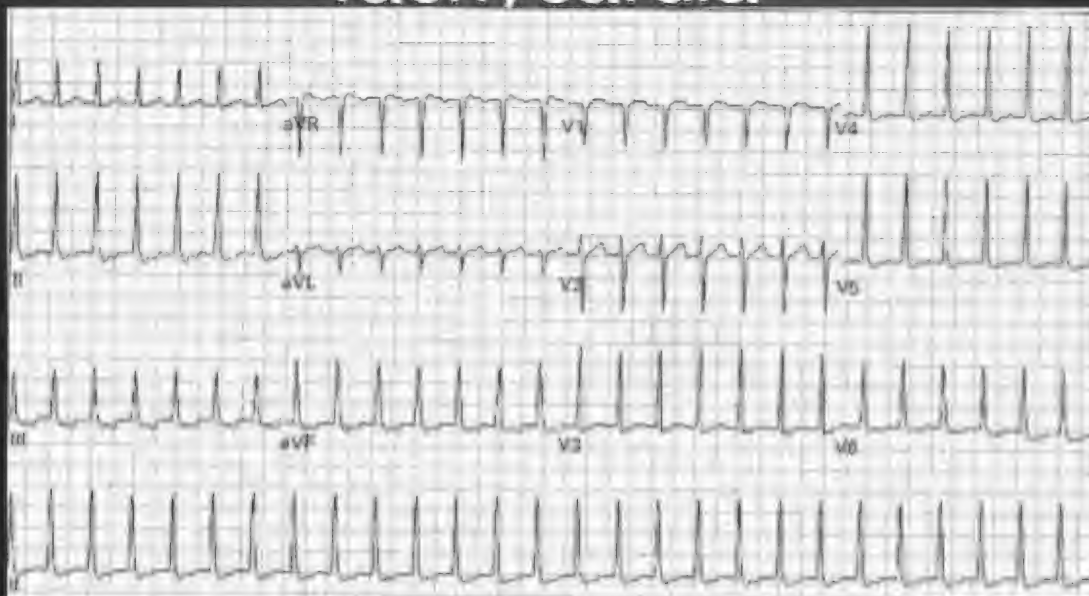
Supraventricular Tachycardia

- Arrhythmia originates "above the ventricles"
 - Usually has a rapid Narrow QRS (ventricular) response
 - Aberrant (abnormal appearing) conduction (SVTAC) can produce a wide-complex tachycardia that may mimic ventricular tachycardia (VT).
- To differentiate SVTs from true VTs
 - If atrial rate > ventricular rate, the rhythm is likely to be an SVT
 - If atrial rate = ventricular rate, the rhythm is likely to be a sinus tachycardia or nodal reentry
 - If the atrial rate < ventricular rate, the rhythm is likely to be a VT

Common Forms of SVT

- **SVTs from a sinoatrial source:**
 - Sinoatrial nodal reentrant tachycardia (SNRT)
- **SVTs from an atrial source:**
 - Ectopic (unifocal) atrial tachycardia (EAT)
 - Multifocal atrial tachycardia (MAT)
 - Atrial fibrillation with a rapid ventricular response
 - Atrial flutter with a rapid ventricular response
 - Without rapid ventricular response, fibrillation and flutter are usually not classified as SVT
- **SVTs from an atrioventricular source (junctional tachycardia):**
 - AV nodal reentrant tachycardia (AVNRT) or junctional reciprocating tachycardia (JRT)
 - Permanent (or persistent) junctional reciprocating tachycardia (PJRT), a form of JRT which occurs predominantly in infants and children but can occasionally occur in adults
 - AV reciprocating tachycardia (AVRT) - visible or concealed (including WPW syndrome)
 - Junctional ectopic tachycardia (JET)

Supraventricular Tachycardia



Narrow complex, regular; retrograde P waves, rate <220

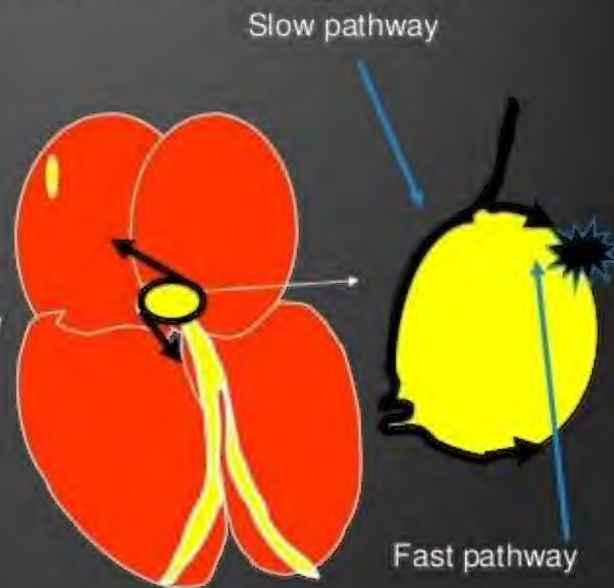
Differential Diagnosis for Narrow QRS Tachycardia



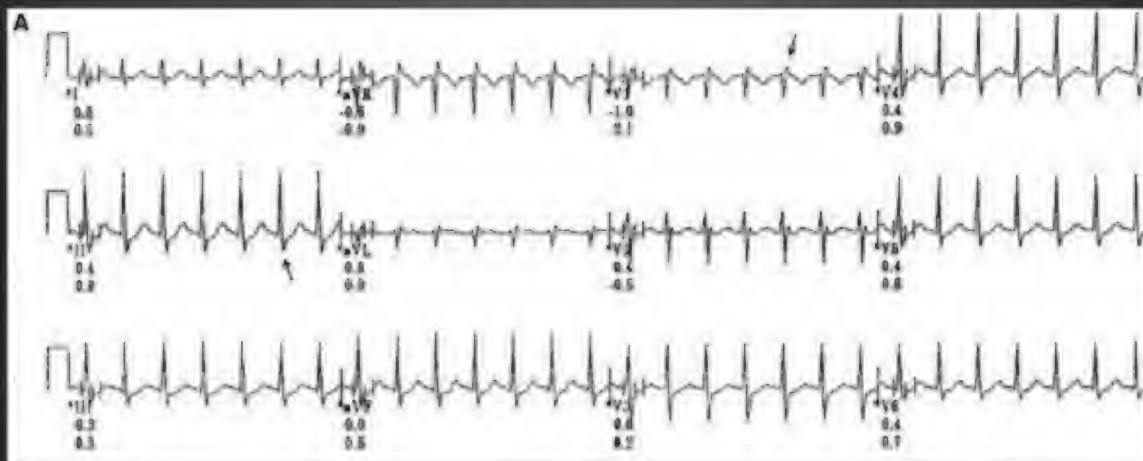
ACC/AHA/ESC guidelines for the management of patients with supraventricular arrhythmias—executive summary. J Am Coll Cardiol. 2003;42(8):1493-1531. doi:10.1016/j.jacc.2003.08.013

AV Nodal Reentrant Tachycardia

- 2 pathways within or limited to perinodal tissue
 - Anterograde conduction down fast pathway blocks with conduction down slow pathway, with retrograde conduction up fast pathway.



ECG Pattern of Typical AVNRT

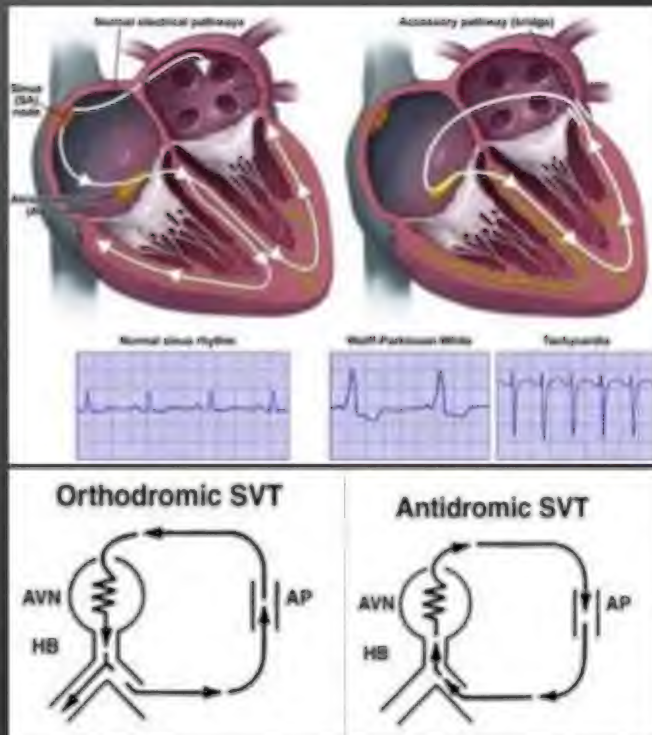


12-Lead ECG shows a regular SVT recorded at an ECG paper speed of 25 mm/sec. Note the pseudo r' in V₁ (arrow) and accentuated S waves in II, III, aVF (arrow). These findings are pathognomonic for AVNRT.

ACC/AHA/ESC guidelines for the management of patients with supraventricular arrhythmias—executive summary. J Am Coll Cardiol. 2003;42(8):1493-1531. doi:10.1016/j.jacc.2003.08.013

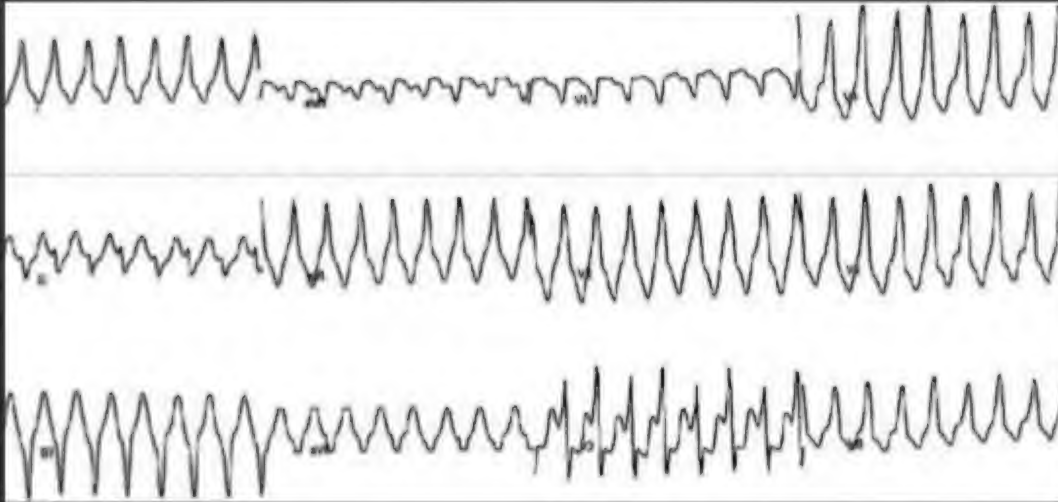
WPW Pathophysiology

- The atrial impulses are conducted partly or completely, prematurely, to the ventricles via a mechanism other than the normal AV-node *



*Moss & Adams

AVRT



- Antidromic atrioventricular reentrant tachycardia,
- Right posteroseptal accessory pathway.
- Note the wide-complex, regular rhythm. The delta waves are more prominent because of maximal pre-excitation.

The 12-Lead Electrocardiogram in Supraventricular Tachycardia. Kumar et al. *Cardiol Clin* 24 (2006) 427–437

AVRT



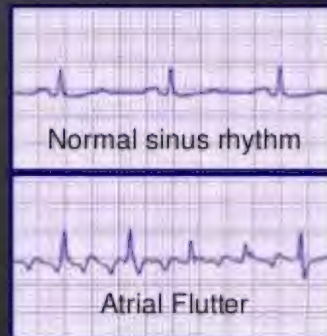
- Orthodromic atrioventricular reentrant tachycardia.
- Note the narrow, regular, rapid tachycardia.
- The P waves buried in the ST segment (short-RP interval) are marked with an arrow.
- No pseudo S/R' waves are seen

The 12-Lead Electrocardiogram in Supraventricular Tachycardia. Kumar et al. *Cardiol Clin* 24 (2006) 427–437

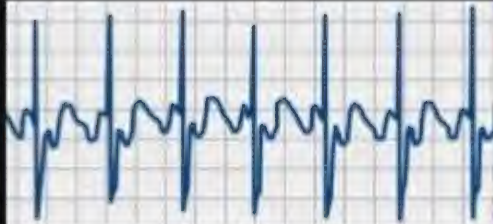
Atrial Flutter

- P waves are present but have a characteristic “saw tooth” appearance
- Two types of flutter
 - Type I is organized – i.e., saw tooth appearance
 - Type II is disorganized and appears as a fib/flutter
- Best observed in leads II, III, and aVF.
- Result of reentry within the atria
- Atrial rate is usually range between 220 - 350

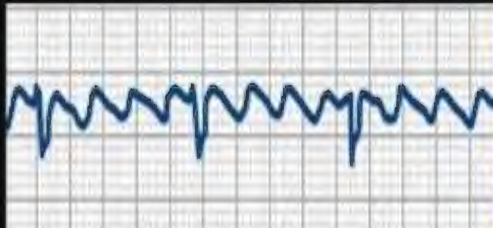
ATRIAL FLUTTER WITH 3:1 CONDUCTION



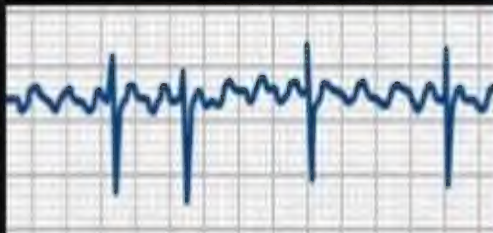
Atrial Flutter



- This atrial flutter shows distinctive atrial beats and the characteristic sawtooth pattern
- Atrial rate here is 250 bpm
- Only every other atrial beat conducts down to the ventricles, so the ventricular rate is 125 bpm



- P-waves are evident
- There are four p-waves to every ventricular beat (4:1 conduction)
- The atrial rate here is 280 bpm

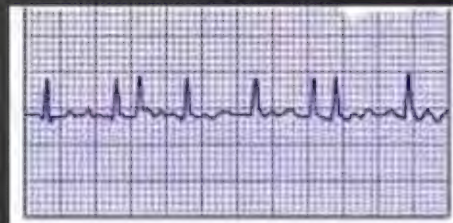


- Atrial flutter with irregular ventricular response
- P-waves are evident; these are "flutter" waves with the characteristic flutter pattern
- Not every P-wave conducts but there is no regular pattern; this indicates AV block

Atrial Fibrillation (AF)

- Disorganized, rapid atrial rhythm
- P-waves not clearly discernible
- Ventricular response is often rapid, may be erratic
- Three main types of AF
 - Paroxysmal
 - Starts suddenly, resolves spontaneously, short episodes, asymptomatic
 - Persistent
 - Longer duration, requires medical intervention, likely symptomatic
 - Permanent
 - Chronic, medically refractory, often severely symptomatic

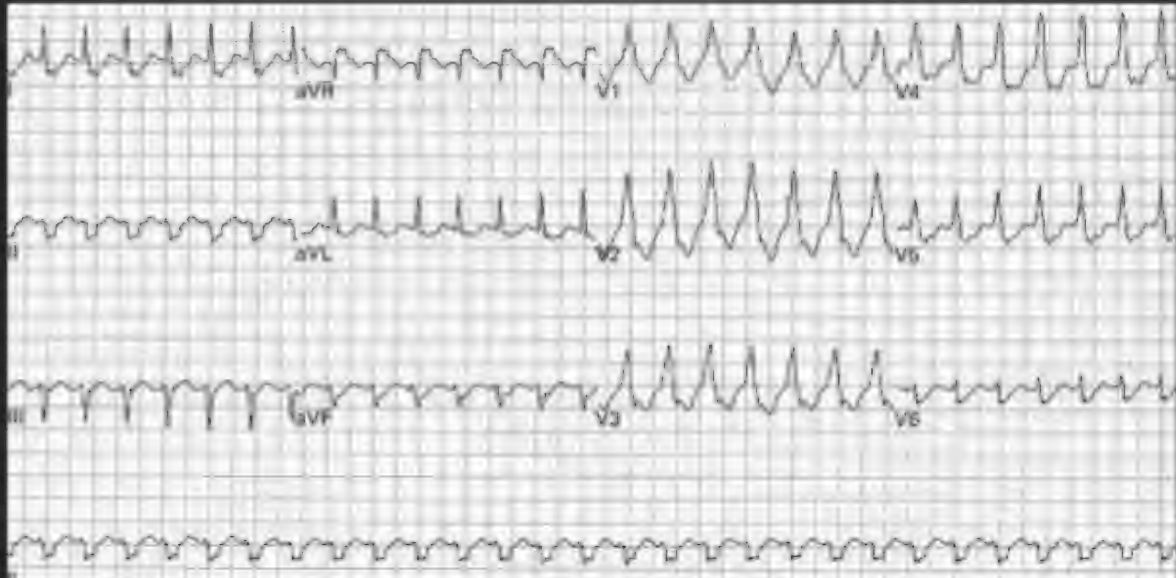
**ATRIAL
FIBRILLATION
(TOTALLY UNCONTROLLED)**



Ventricular Tachycardia (VT)

A VT is an abnormally fast rhythm that originates within the ventricles, or more specifically in the region below the His bundle.

Ventricular Tachycardia

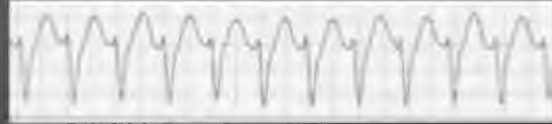


Classification : Etiology

- Ischemic (Post MI)
 - Scar related
 - Slow conduction pathways
 - Re-entry mechanism
- Idiopathic VT
 - Not associated with any SHD – unknown cause
 - Usually Focal mechanism
 - Monomorphic
 - RVOT (85%), RV inflow, RV inferior wall
 - LV "outflow tract"
 - LCC, RCC, NCC
 - coronary venous system
 - LV idiopathic VT (verapamil sensitive)
 - Basal LV
 - Papillary muscles

Classification : Morphology & Duration

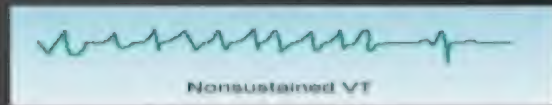
- **Monomorphic VT** - has one QRS shape or morphology



- **Polymorphic VT** - has more than one QRS shape.



- **Nonsustained VT** - short bursts of complexes lasting less than 30 seconds.



- **Sustained VT** - complexes lasting at least 30 seconds or that require intervention in less than 30 seconds



Distinguishing VT from SVT

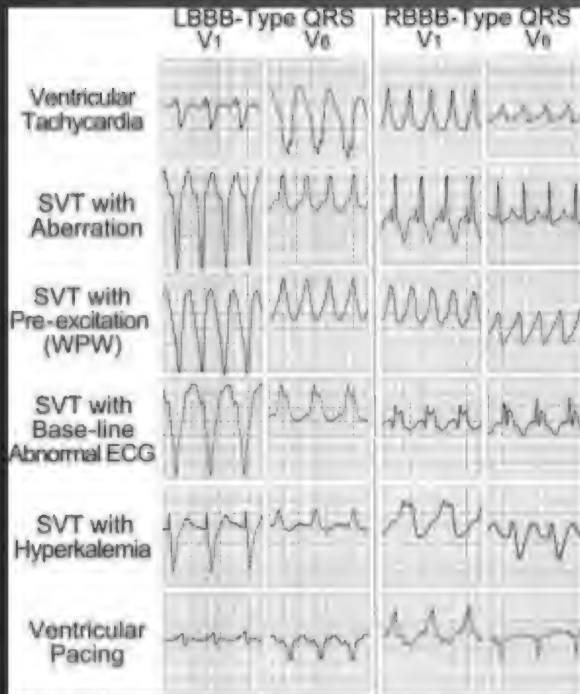
VT	SVT
AV dissociation is present in 50% of patients	AV dissociation is never present.
Inducible from the ventricle, but not the atrium.	Inducible from the atrium.
QRS duration is often > 140 ms.	QRS duration is often < 140 ms.
QRS axis is usually < -30°.	QRS axis is usually > -30°.
No response to adenosine.	Adenosine either restores the sinus rhythm or causes transient rhythm changes.
QRS morphology is atypical for bundle branch block or preexcitation.	QRS morphology may indicate bundle branch block or preexcitation (Delta wave).

Ventricular tachycardia (VT) is diagnosed by demonstrating that the atria are not part of the VT mechanism. Since all VTs are potentially life-threatening, it is critical to distinguish VT from SVT with aberrant conduction.

- AV dissociation is present in 50% of patients with VT. It is never present in SVT. During VT, retrograde conduction over the AV node does not occur. Thus if AV dissociation occurs during extrastimulus pacing but the tachycardia continues, the rhythm is almost always VT (Murgatroyd 2002).
- The table provides information for distinguishing VT from SVT with aberrancy.

More than 95% of patients with previous myocardial infarction and wide-complex QRS have VT regardless of symptoms (Eggenes 1999).

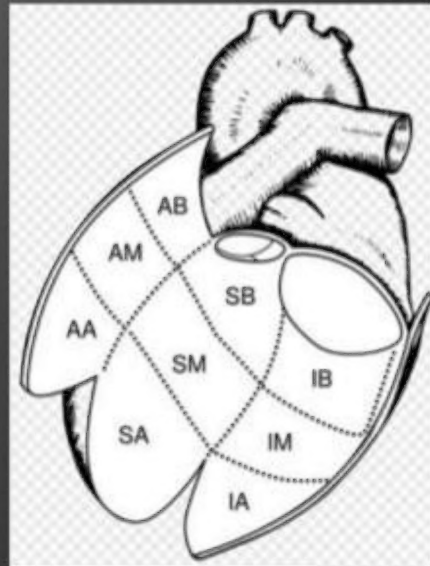
QRS Complexes in different types of WCT

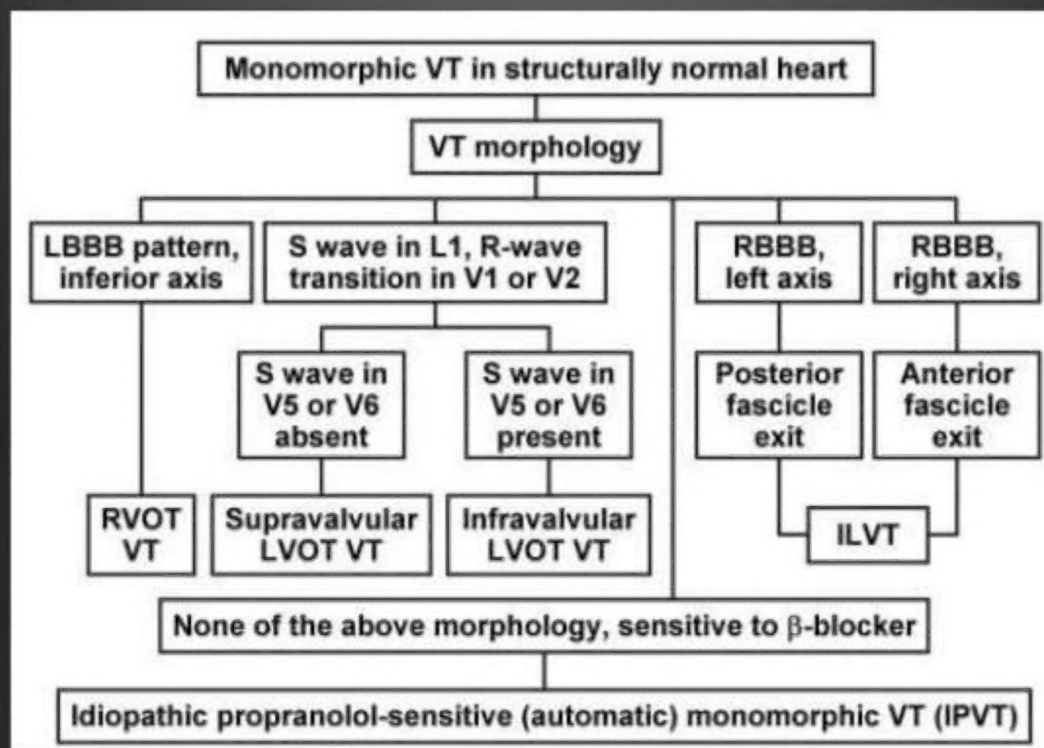


Examples of leads V₁ and V₆ in both left bundle branch block and right bundle branch block types of QRS complexes in different types of wide complex tachycardia. ECG, electrocardiogram; SVT, supraventricular tachycardia; WPW, Wolff–Parkinson–White syndrome.

VT Localisation

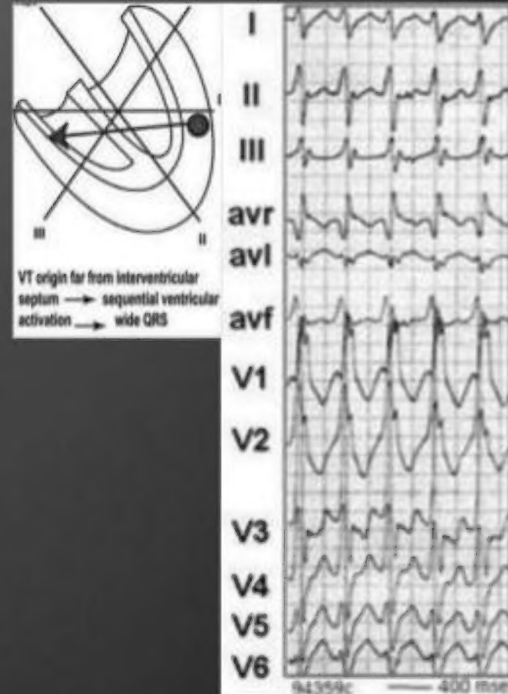
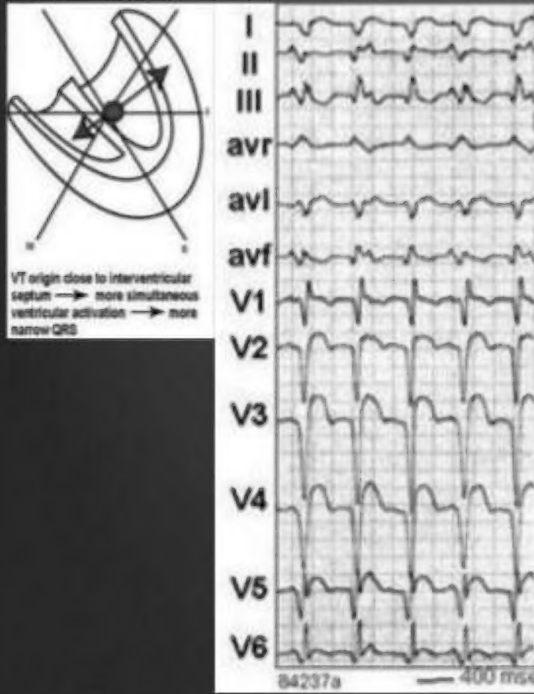
- ✿ The steps to finding the exit site are:
 - ✿ What is the bundle branch block (BBB) configuration?
 - ✿ What is the inferior lead QRS complex polarity?
 - ✿ What is the lead I QRS complex polarity?
 - ✿ What is the lead aVL QRS complex polarity?
 - ✿ What is the lead aVR QRS complex polarity?
 - ✿ Where is the R-wave transition point?





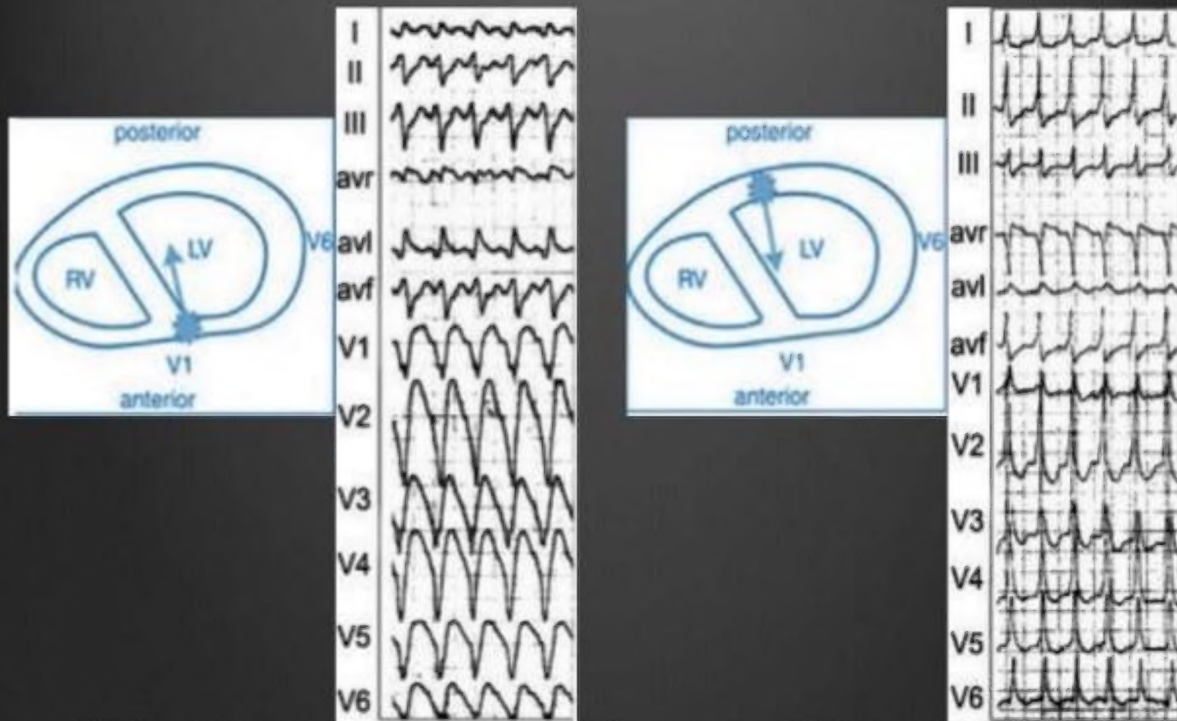
Ventricular Tachycardia in the Absence of Structural Heart Disease. Srivathsan K, Lester SJ, Appleton CP, Scott LR, Munger TM - Indian Pacing Electrophysiol J (2005)

Localization of VT



Using the twelve-lead electrocardiogram to localize the site of origin of ventricular tachycardia. Mark E. Josephson, MD, a David J. Callans, MD

Localization of VT



Using the twelve-lead electrocardiogram to localize the site of origin of ventricular tachycardia. Mark E. Josephson, MD, a David J. Callans, MD